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Phytoremediation with Transgenic Trees

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In the present paper actual trends in the use of transgenic trees for phytoremediation of contaminated soils are reviewed. In this context a current field trial in which transgenic poplars with enhanced GSH synthesis and hence elevated capacity for phytochelatin production are compared with wildtype plants for the removal of heavy metals at different levels of contamination and under different climatic conditions. The studies are carried out with grey poplar (*Populus tremula* x *P. alba*), wildtype plants and plants overexpressing the gene for γ-glutamylcysteine synthetase (*gshI*) from *E. coli* in the cytosol. The expression of this gene in poplar leads to two- to four-fold enhanced GSH concentrations in the leaves. In greenhouse experiments under controlled conditions these transgenic poplars showed a high potential for uptake and detoxification of heavy metals and pesticides. This capacity is evaluated in field experiments. Further aims of the project are to elucidate (a) the stability of the transgene under field conditions and (b) the possibility of horizontal gene transfer to microorganisms in the rhizosphere. The results will help to assess the biosafety risk of the use of transgenic poplar for phytoremediation of soils.

Key words: Phytoremediation, Transgenic Trees, Poplar

Introduction

After decades or even centuries of human activities in industry, mining, or military a huge amount of area in developed countries shows high contamination with heavy metals or organic pollutants. Therefore, phytoremediation, *i.e.*, bioremediation with plants, of polluted soils has received significant attention (Cunningham and Ow, 1996; Gleba *et al.*, 1999; Meagher, 2000; Dietz and Schnoor, 2001). Phytoremediation is an emerging new technology that uses plants to remove or degrade various pollutants from soils. A number of plant species are able to accumulate high amounts of heavy metals in their above-ground tissues or to degrade various organic soil pollutants (Salt *et al.*, 1998; Kömives and Gullner, 2000).

Exposure of plants to heavy metals induces synthesis of compounds that chelate these metals and thus contribute to their detoxification (Rauser, 1999). Among the chelators, sulfur-rich peptides, *i.e.* metallothioneins and phytochelatins, are of particular importance. Metallothioneins are sulfur-rich proteins of 60–80 amino acids containing 9–16 cysteine residues (Hamer, 1986; Robinson *et al.*, 1993; Rauser, 1999). Phytochelatins (PC) are a family of γ-glutamylcysteine oligopeptides with glycine or other amino acids as the C-terminal constituent (Grill *et al.*, 1985; Rauser, 1999). The γ-Glu-Cys units are repeated 2–7 times. The C-terminal amino acids of phytochelatins include β-Ala, Cys, Ser, or Glu (Grill *et al.*, 1986; Klapheck *et al.*, 1994; Rauser, 1999). Phytochelatins are synthesised from glutathione (GSH) and its derivates by phytochelatine synthase in the presence of heavy metal ions (Vatamaniuk *et al.*, 1999; Ha *et al.*, 1999) (see Fig. 1). The gene encoding phytochelatine synthase was recently cloned from *Arabidopsis* and yeast (Vatamaniuk *et al.*, 1999; Ha *et al.*, 1999; Clemens *et al.*, 1999). Following Cd or Cu exposure, PCs were found in yeast, algae, lower and higher plants (Kondo *et al.*, 1984; Gekeler *et al.*, 1988, 1989). Cadmium is the most effective inducer of PCs, but Cu, Pb, Zn, Sb, Ag, Zn, or Hg also induce their formation (Grill *et al.*, 1987; Maitani *et al.*, 1996). PCs form ligand complexes with these metals which are further sequestered into the vacuoles. Mutants in PC synthesis are hypersensitive to Cd and other metals (Howden *et al.*, 1995).

Abbreviations: γ-EC, γ-L-glutamyl-L-cysteine; γ-ECS, γ-glutamylcysteine synthetase; GSH, glutathione; GSSG, oxidized glutathione; GST, glutathione *S*-transferase.

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